# ENGINE ICING CAPABILITY ENHANCEMENTS FOR PROPULSION SYSTEMS LABORATORY

The AC9C is holding their biannual committee meeting in Ottawa, Ontario on 18-20 October 2010. I have been asked to provide a short presentation of the status of the icing project upgrade to the PSL test facility. I will highlight the progress made during construction the past 6 months, our approach for checkout of the facility, and an overview of the system design and its capabilities. A copy of the presentation is attached.

# Engine Icing Capability Enhancements For Propulsion Systems Laboratory

## John H. Glenn Research Center at Lewis Field

## Project Update to the SAE AC9C Committee

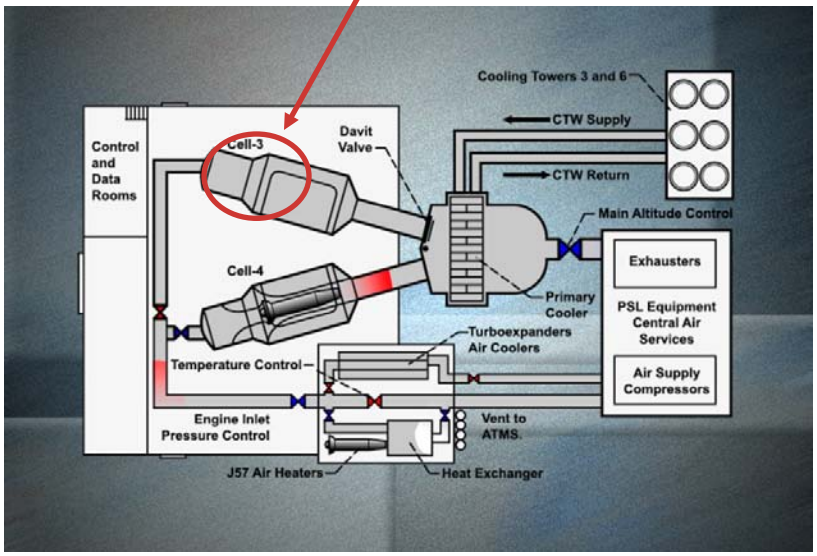
October 19, 2010

Tom Griffin
PSL Project Lead

# PSL Icing
# Goals and Future of Upgrade

- **Enhance PSL to provide industry and government a facility that will address turbine engine core icing.**
- **Collaborate with industry/other government agencies to plan utilization of system.**
- **Build system that is versatile so it can be refined to meet developing engine icing requirements.**

***Location of Upgrade***

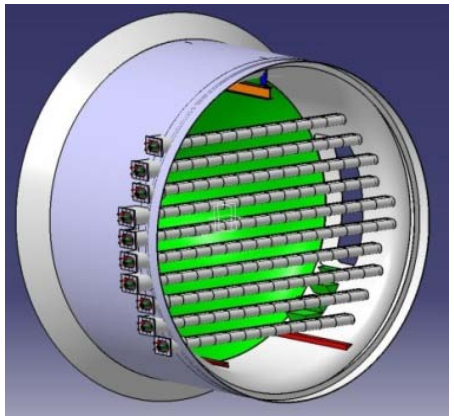


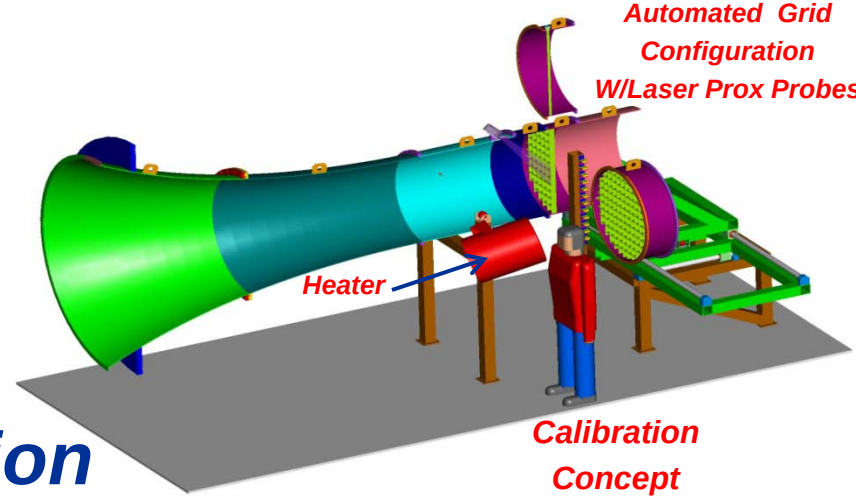
# Facility Icing Upgrade Progress/Plan

- Complete Icing System Installation in Summer 2011
  - Construction at 64% complete
  - Spray bar fabrication is proceeding
- Prepare for System Startup
  - Perform Technology Demonstration Tests in Cox Icing Tunnel
  - Develop hardware, instrumentation, controls, cameras, etc for tests
- Integrated Systems Test
  - System Checkouts
  - Full up Icing System Check
- Calibration Test
  - Verify Requirements are met
  - Document System Capabilities
- Validation Test
  - Seeking a cooperative test with engine manufacturer
  - Validate Against Existing Flight Data

# PSL Icing
# System Description and Capabilities

***Plenum***

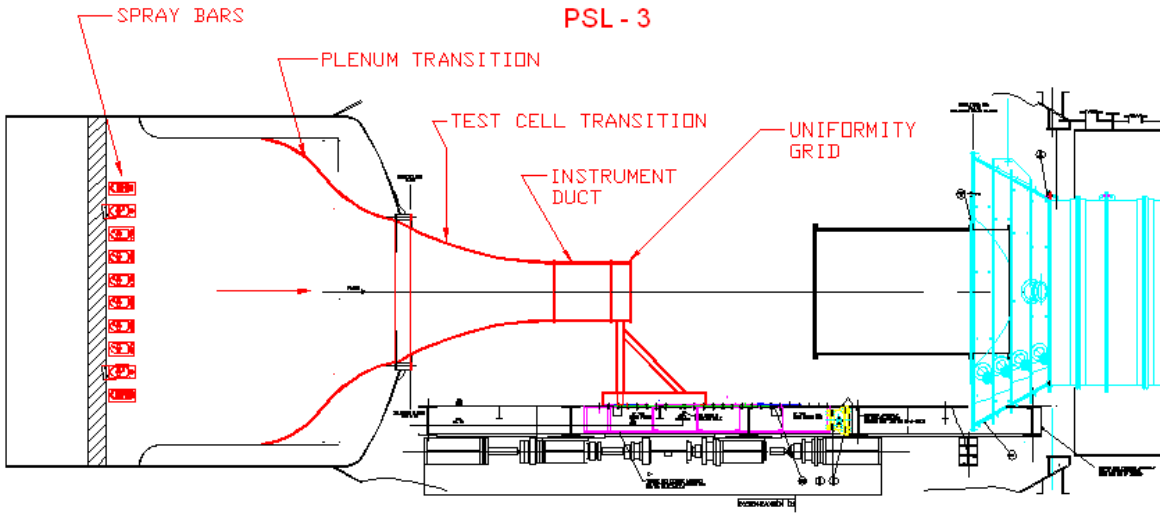


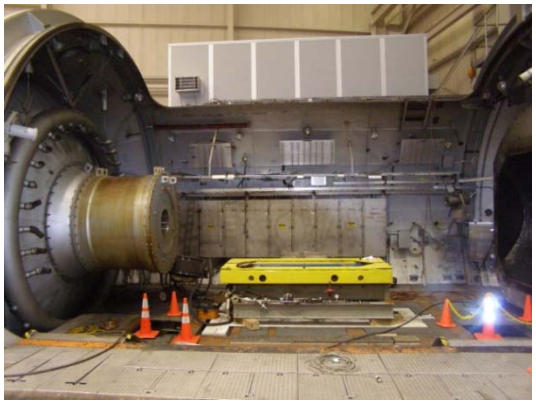



***Automated Grid Configuration W/Laser Prox Probes***

***Calibration Concept***

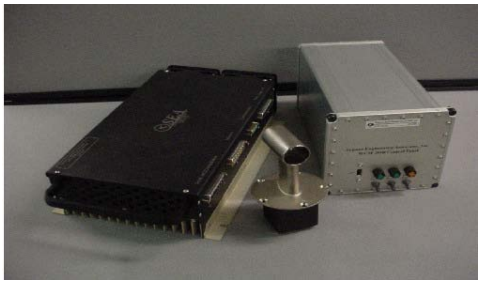
## *Icing Configuration*

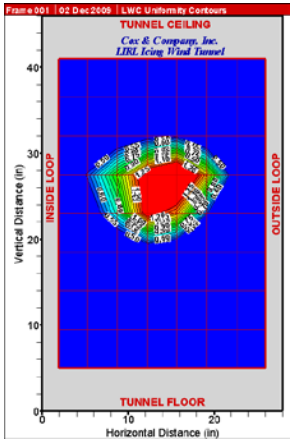


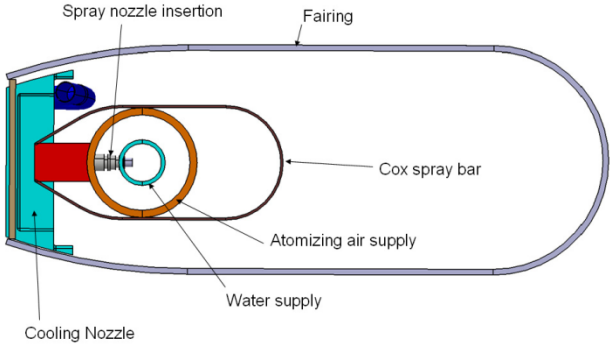



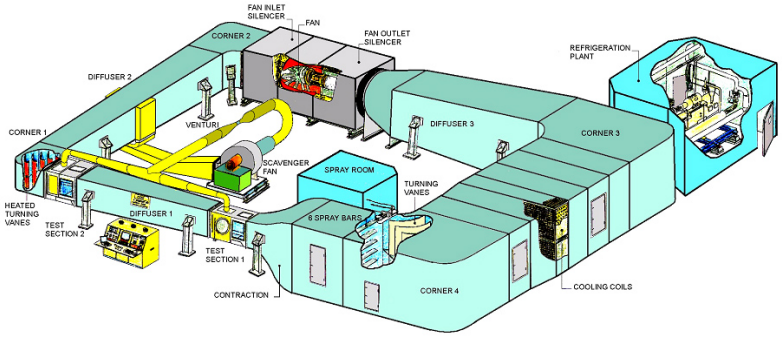
# Technology Demonstration Tests Summary

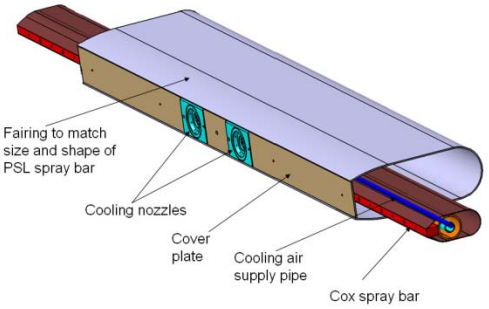
- Proof of concept for generating ice particles
- Parametrics include Tunnel speed and temperature, Nozzle type, Cooling air pressure and temperature, Spray bar atomizing air and water pressures and temperatures
- Grid establishes cloud size, uniformity and center for instrument placement
- FSSP and OAP used to determine median volume droplet size (MVD) and distribution
- Multi-wire probe used to determine liquid and total water content (LWC, TWC) and freeze fraction





# PSL Icing Capability to Meet Engine Core Icing Research Needs

Unique features PSL will provide:

- ✓ Altitude capability: (4000-40,000 ft.) No other existing engine facility can provide this capability.
- ✓ Ice Water Content: (0.5-9.0 g/m3) Very large range of water content is unique to HIWC icing. It is a key parameter to study the problem.
- ✓ Air Temperature: (15 to -60 deg F) Most existing and planned engine core icing test facilities are reliant upon cold weather for air supply temperature or have limited air temperature ranges. PSL provides a unique, wide range of temperatures.
- ✓ Full operating engine test capability will permit validation testing with a high confidence level.

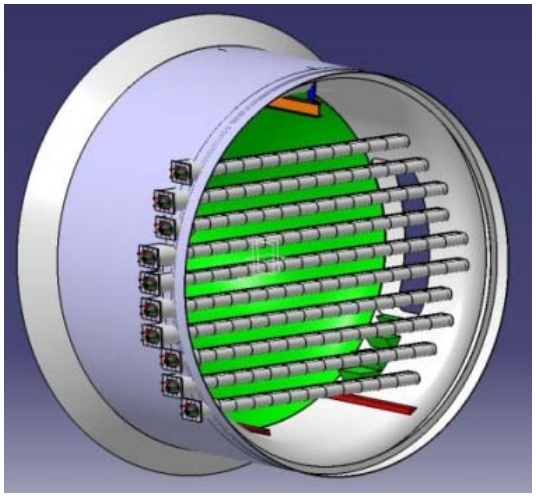
# Technical Requirements For PSL Icing

| Specified Requirement | | |
|---|---|---|
| **Specification** | **Minimum** | **Maximum** |
| Altitude (pressure) | 4000 ft | 40,000 ft |
| Inlet Total Temperature | -60°F | 15°F |
| Mach Number | 0.15 | 0.80 |
| Air Flow Rate | 10 lbm/sec | 330 lbm/sec |
| IWC (icing water content) | 0.5 g/m$^3$ | 9.0 g/m$^3$ |
| MVD (mean volumetric diameter) | 40µ | 60µ |
| Run Time | Continuous up to 45 minutes | |

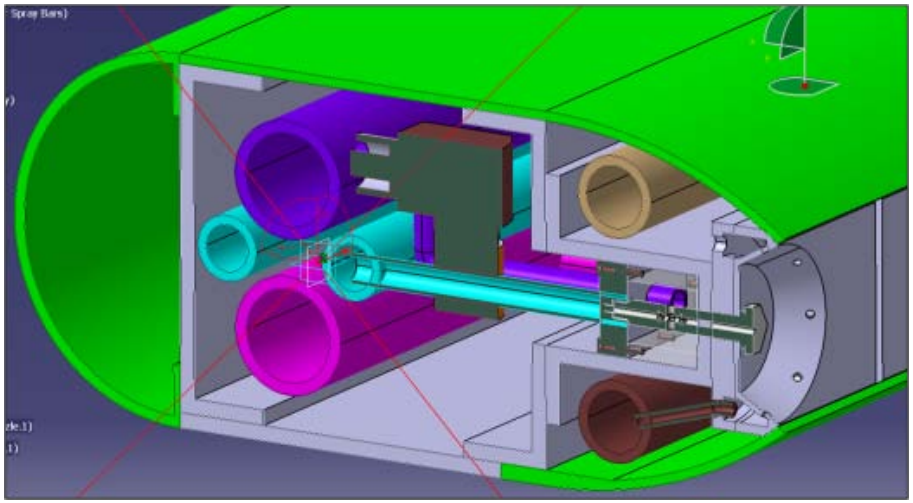
- Requirements were created in conjunction with EHWG

# PSL Icing
# System Description and Capabilities

- **10 Spray Bars of 200+ Nozzles (2 types) mounted in PSL3 plenum that spray 35 F atomized water. Spray is cooled with -40 F air at nozzle exit to enhance freezing.**
- **System to be operated and controlled by the PSL Facility Control System from the Control Room**
- **System emphasizes versatility, flexibility and portability. Spray bars are removable**



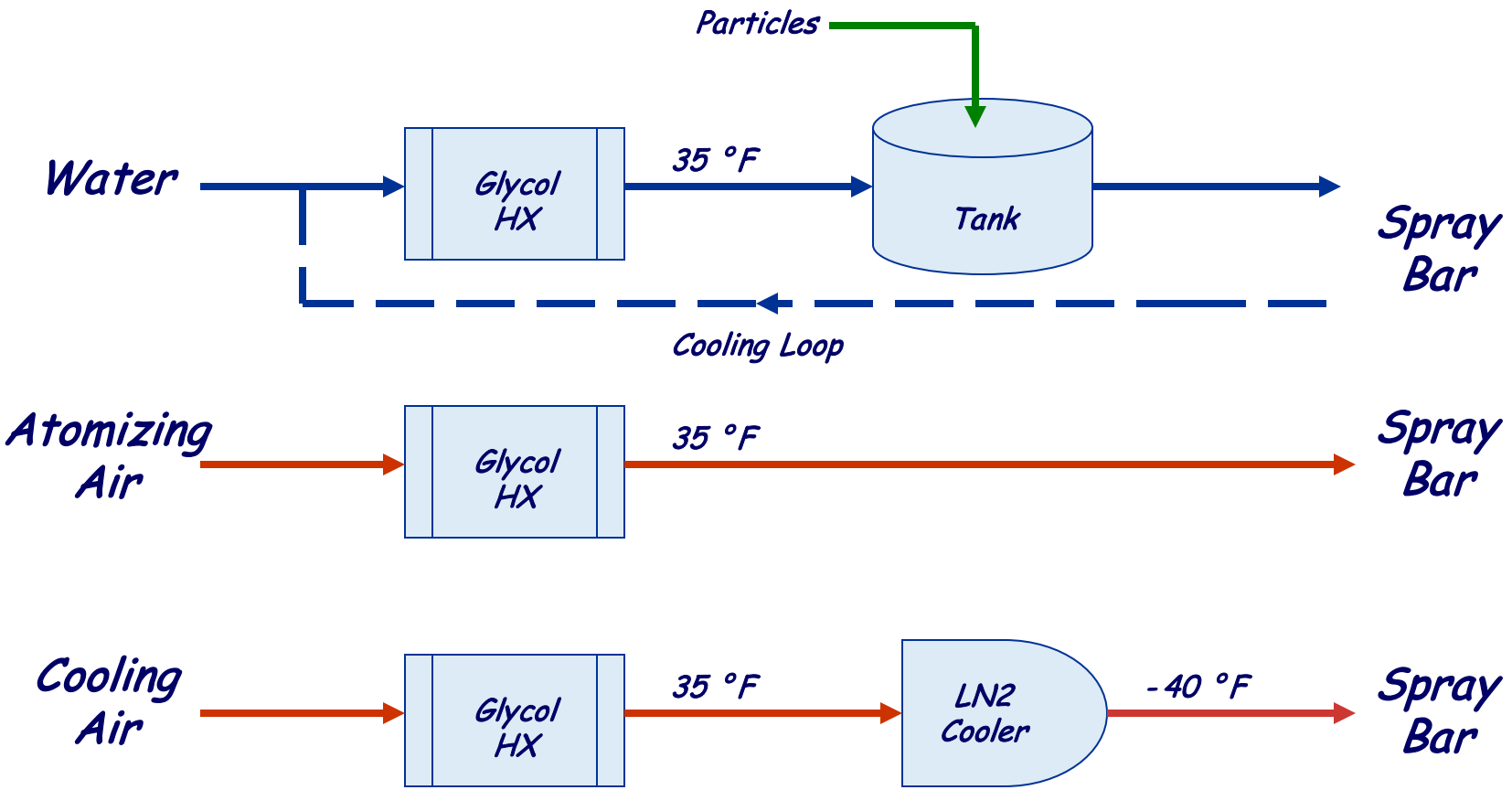
PSL 3 Plenum Spray Bars



Spray Bar Detail

# PSL Icing
# System Description and Capabilities

## *Subsystems Design Summary*



# PSL Icing Progress

Water Tank

Air Dryer

Cooling/Atomizing Air HX

Glycol Chiller

Nitrogen Dewer

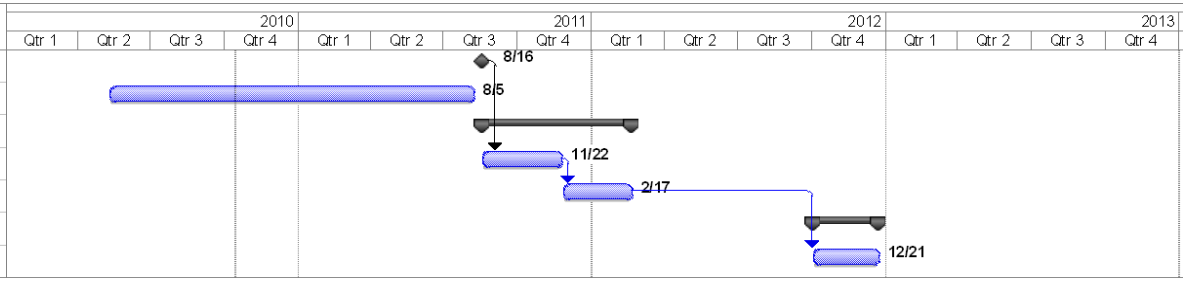

Glycol/Water HX

Water Supply and Return Pipe
Atomizing and Cooling Air Supply

CONTROLS

# Facility Activation Schedule

| ID | Task Name |
|---|---|
| 1 | Icing System Construction Ends |
| 2 | Develop Associated System Hardware |
| 3 | **Facility Activation** |
| 4 | Integrated Systems Test |
| 5 | Calibration Test |
| 6 | |
| 7 | Validation Test |




# Questions/Comments !